

TECHNOLOGY UTILIZATION

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CABLES AND CONNECTORS

A COMPILATION

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

This document is one in a series intended to furnish such technological information. Divided into three sections, the Compilation presents devices and techniques for various types of electrical cables and connections. The first section contains several items on recently-developed flat conductor cable (FCC) technology, the second section describes a number of new electrical connectors, and the third section contains several additional articles on cables and connectors.

Additional technical information on items in this Compilation can be requested by circling the appropriate number on the Reader Service Card included in this Compilation.

The latest patent information available at the final preparation of this Compilation is presented on the page following the last article in the text. For those innovations on which NASA has decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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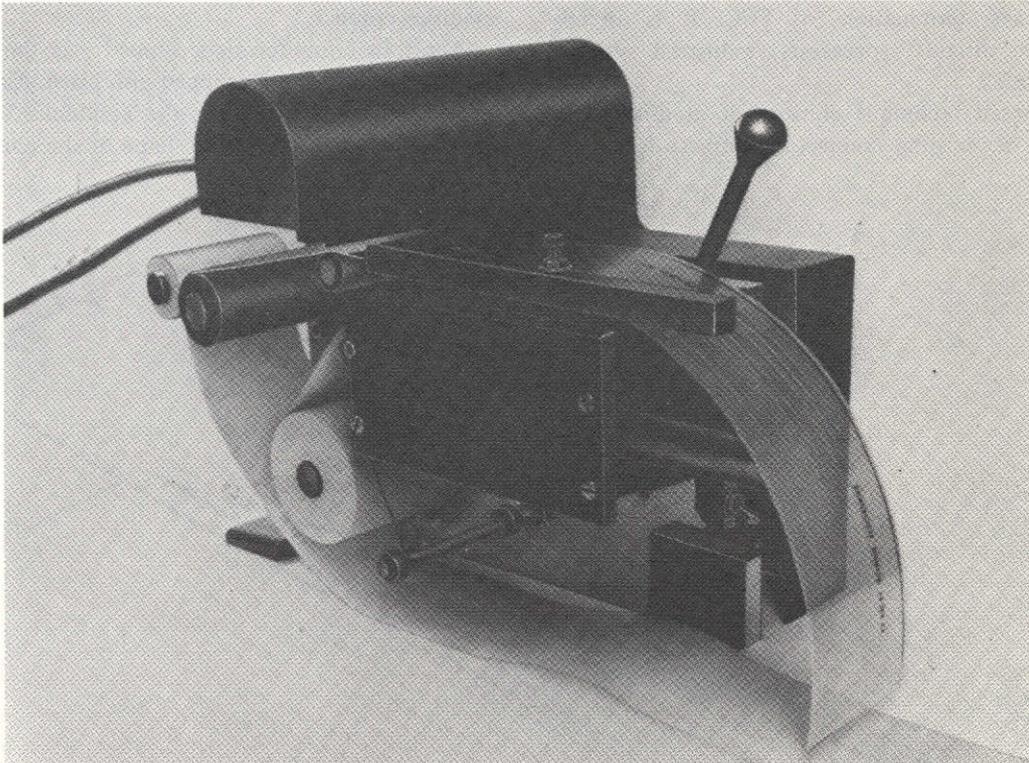
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Section 1. Flat Conductor Cable Technology

HOT-BLADE STRIPPER FOR POLYESTER INSULATION ON FCC



Hot-Blade Stripper

The hot-blade stripper is designed to strip polyester film from unshielded flat conductor (copper) cables. Stripping by conventional mechanical means is difficult because of the strong adhesion between the polyester and the copper surfaces. The stripper incorporates a blade which is electrically heated to a controlled temperature [370° to 430° C (698° to 806° F)].

The heated blade, brought down on the cable while it is slowly pulled beneath the blade, softens and strips the insulation. A paper ribbon moves away from the blade and removes the stripped insulation material, keeping the blade clean for the next operation. When

the cable clears the blade, the blade lifts, the cable is turned over, and the stripping operation is repeated on the opposite side. The stripped conductors are cleaned with pumice and, if required, with a commercial stripping solution.

Source: C. M. Chambers and W. Angele
Marshall Space Flight Center
(MFS-20117)

Circle 1 on Reader Service Card.

REPAIRABLE FLAT CONDUCTOR CABLE (FCC) CONTACTS FOR EXISTING ROUND CONNECTORS: A CONCEPT

A new concept for connector termination of flat conductor cable (FCC) provides a method for the repair of both the connector contacts and the FCC. In addition, it provides the capability to terminate FCC directly to existing, environmental-type, round connectors. The idea should be of interest to any industry considering the utilization, and subsequent fabrication and termination, of FCC. It is directly applicable to aircraft, spacecraft, industrial systems, and automobiles.

The proposed technique consists of modifying the end barrels of existing connector contacts in such a

way that flat conductor cable can be assembled directly to the contacts by split crimp-ferrules. The end barrel of a contact, a solid piece, is modified by cutting grooves in it (Figure 1). These grooves are rounded to eliminate any damage to the FCC conductor. Assembly then may be accomplished by removing sufficient insulation from the FCC conductor so that it may be positioned on the modified contact.

The split crimp-ferrule is slipped over the conductor and the contact and is crimped into place. As the ferrule is crimped into place over the conductor, the ferrule and the conductor take the shape of the contact barrel

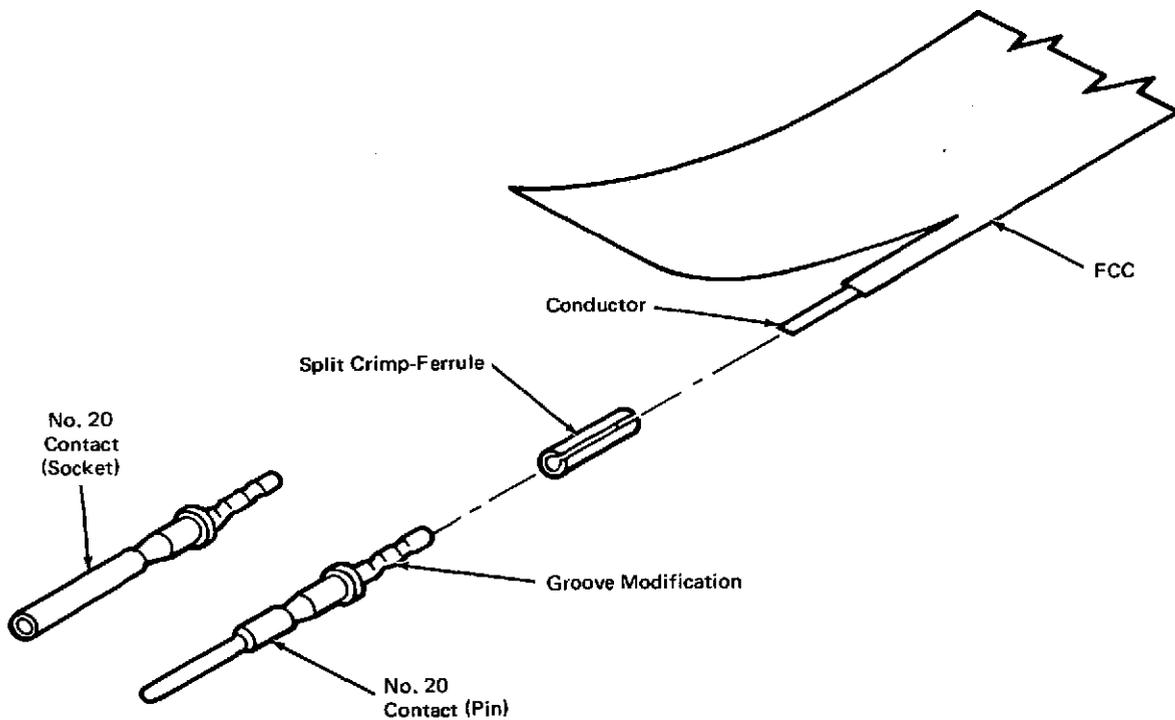


Figure 1. FCC Termination With Modified Connector Contacts

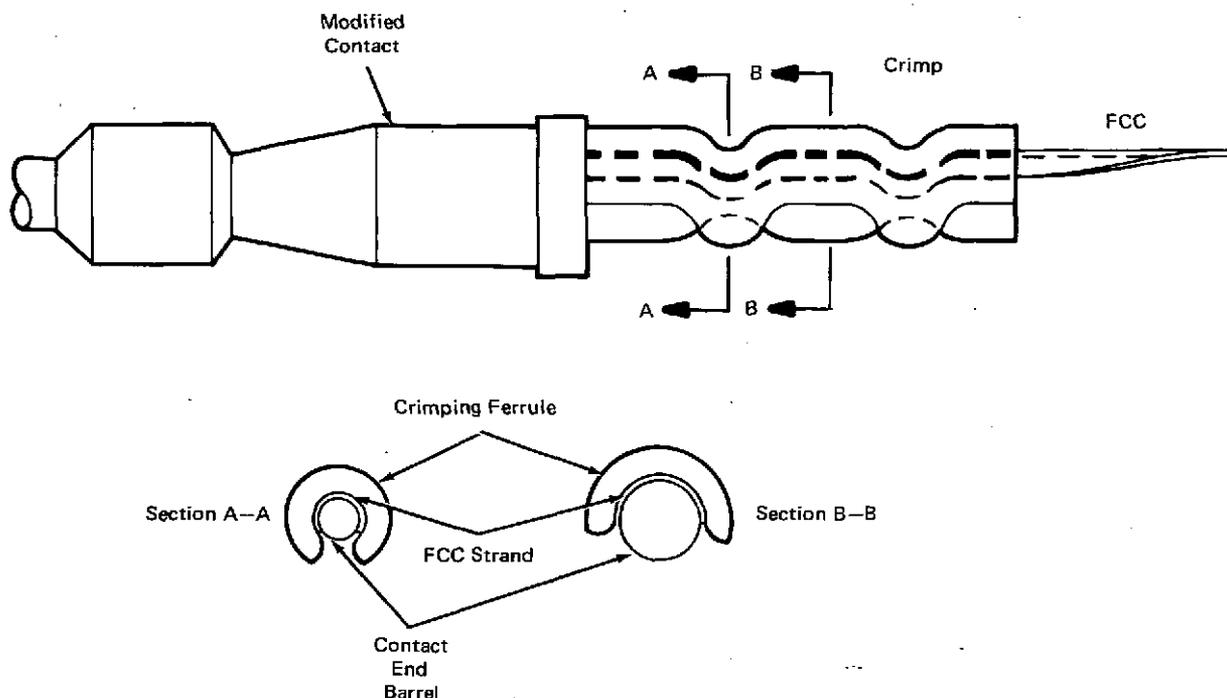


Figure 2. Assembled Contact and FCC Conductor

(Figure 2), making a permanent mechanical and electrical, in-line, secured connection. The FCC is repairable because the crimp-ferrule can be removed easily without any damage, if disassembly is required. Circuits may be changed, added, or removed; and bent or misaligned contacts may be repaired.

It is possible that the rear grommet of the connector will have to be modified to provide a moisture seal, not only for the contact but also for that portion of the FCC insulation that is flat. The grommet may be made in two sections, one having holes for the contacts and a second having slits for the FCC. The two

sections then can be molded together, making a single grommet assembly that will continue to provide an environmental seal.

Source: E. J. Stringer and
J. D. Doyle of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24140)

Circle 2 on Reader Service Card.

REPAIRABLE, TRANSITIONAL FCC CONNECTOR

A method has been devised for the fabrication of flat conductor cable (FCC) termination in a connector. The method is novel in that the connection is protected from the environment, yet is repairable. The simplicity of this method allows broken FCC to be restored in field-maintenance situations without elaborate repair equipment.

The technique for the fabrication of repairable FCC terminations consists of a four-step stripping, parts mating, and installation process (see Figure 1). The flat conductor cable first is pushed through the grommet far enough to allow stripping of the insulation from the

conductor and the permanent mechanical assembly of the conductor and the contact. The cut in the grommet is a narrow long slash that allows the FCC to be pushed through. When the insulation has been removed from the conductor, the conductor is placed within the selected opening of the conductor shell body.

The back end of the contact has been designed to allow tension within the round surface; it is slightly larger than the opening within the shell body. The contact is pushed into the opening of the shell body where the conductor is located; there it applies a tension force to the sides of the conductor, holding it in place.

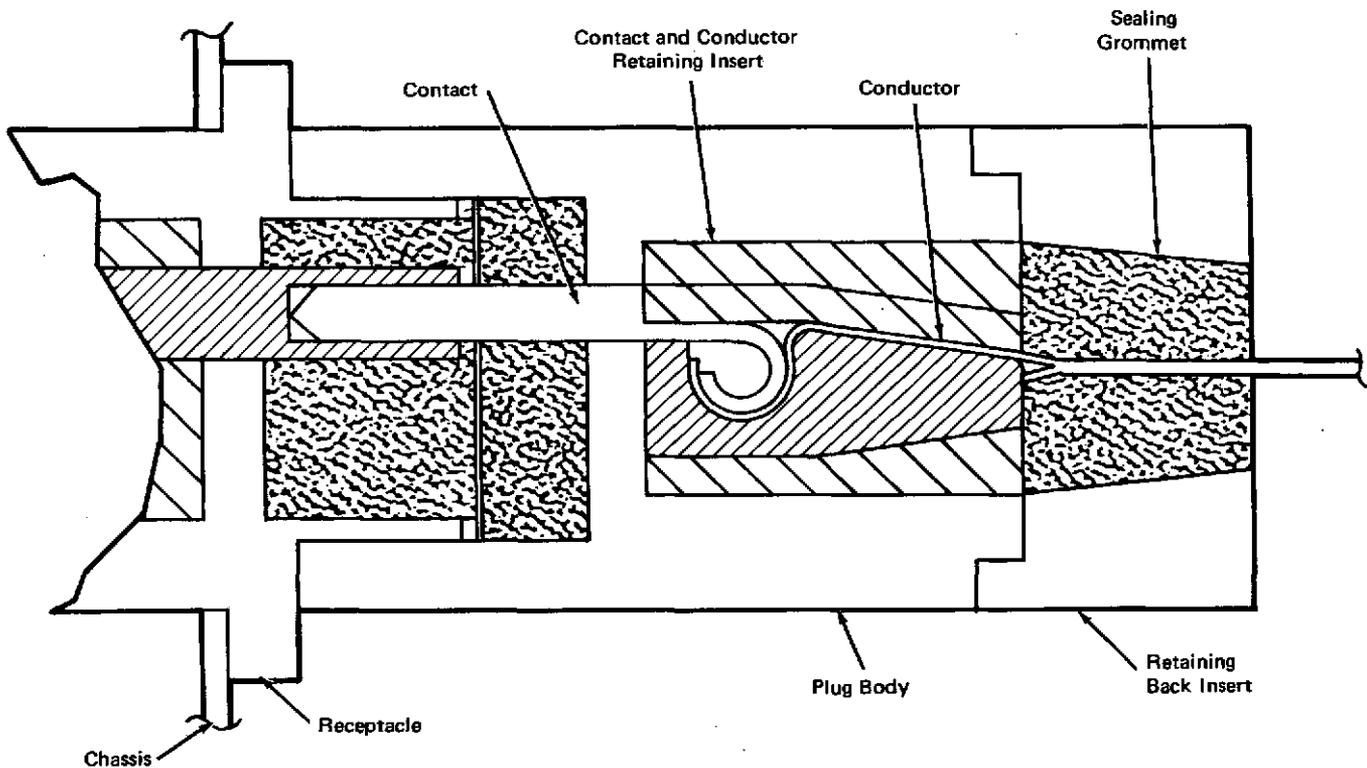


Figure 1. Assembled Connector

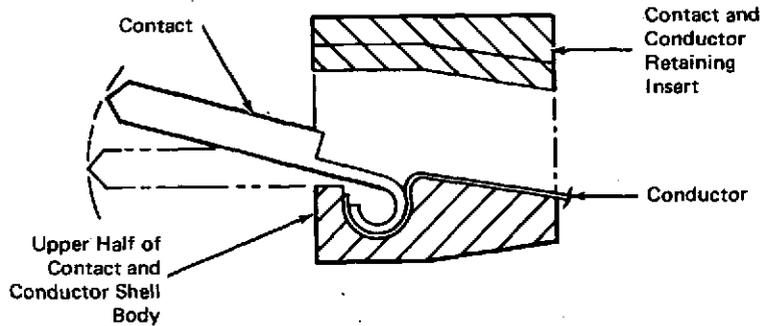


Figure 2. Connector Contact

The contact also has been designed so that it is slightly higher than the shell body (Figure 2).

After the contact and the conductor are assembled within the connector body, the retaining insert is placed in back of the body and secured. The taper within the insert allows pressure to be applied against the grommet and in turn against the FCC, providing a seal against moisture.

Source: E. J. Stringer and
J. A. Walling of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24117)

Circle 3 on Reader Service Card.

LOAD-CARRYING AND THERMAL CHARACTERISTICS OF FLAT CONDUCTOR CABLE

The load-carrying and thermal characteristics of flat conductor cable (FCC) and round wire cables are described in a recent report. The report includes graphs that summarize measurements of current versus temperature rise and of temperature-rise profiles in air and in vacuum. In addition, the factors for uprating the current-carrying capacity of FCC, from that of round wire of the same gauge, are given; for example:

Cable Type	Uprating Factors	
	In Air	In Vacuum
Single-Layer Cable	1.50	1.55
3-Layer Cable	1.35	1.50
10-Layer Cable	1.05	1.05

When operating in a vacuum, all cables must be down-rated to 55 percent of the rated capacity in air. Single-layer flat cable may be operated in a vacuum at 60 percent of the air-rated load.

Temperature distributions in fully loaded cables have

been found by measuring the change in resistance of the conductors as a function of the change in temperature:

$$T_2 - T_1 = \frac{R_2 - R_1}{R_1 \alpha}$$

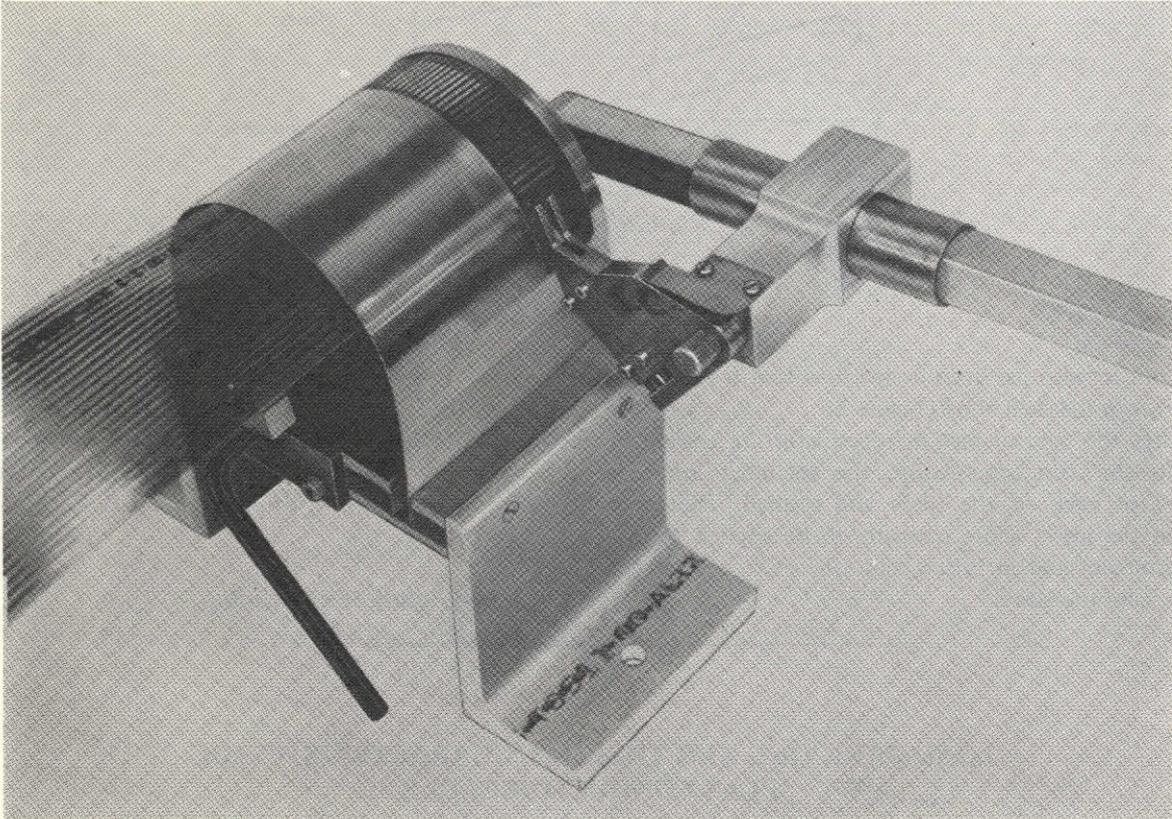
where T_1 is the initial temperature, T_2 is the unknown temperature, R_1 is the initial resistance at T_1 , and R_2 is the resistance at T_2 . The temperature coefficient α in ohms/ohm/°C closely agrees with the published value of 0.00393 (0.00398).

The report also discusses the effects of horizontal or vertical mounting of FCC, which is found to make little difference in the heat rise of a full loaded cable in air. Convection cooling shifts the position of the hottest wire but does not affect its maximum temperature.

Source: G. D. Adams
Marshall Space Flight Center
(MFS-22841)

Circle 4 on Reader Service Card.

ROTARY STRIPPER FOR SHIELDED AND UNSHIELDED FCC



Rotary Stripper

A bench-type tool (see figure) may be used for stripping shielded and unshielded flat conductor cables. Unshielded cables can be stripped on both sides with a single stroke; shielded cables must be stripped in steps of different depths to leave the shields clear for grounding and the conductors clear for terminating. Stripping must be performed in such a way as to prevent electrical continuity or arcing between the shields and conductors when the cable is terminated with a plug. The rotary stripper will remove narrow strips of insulation and shielding to any desired depth. By successive rotations of the blade, the tool removes any required width of outer insulation, shield, and inner insulation.

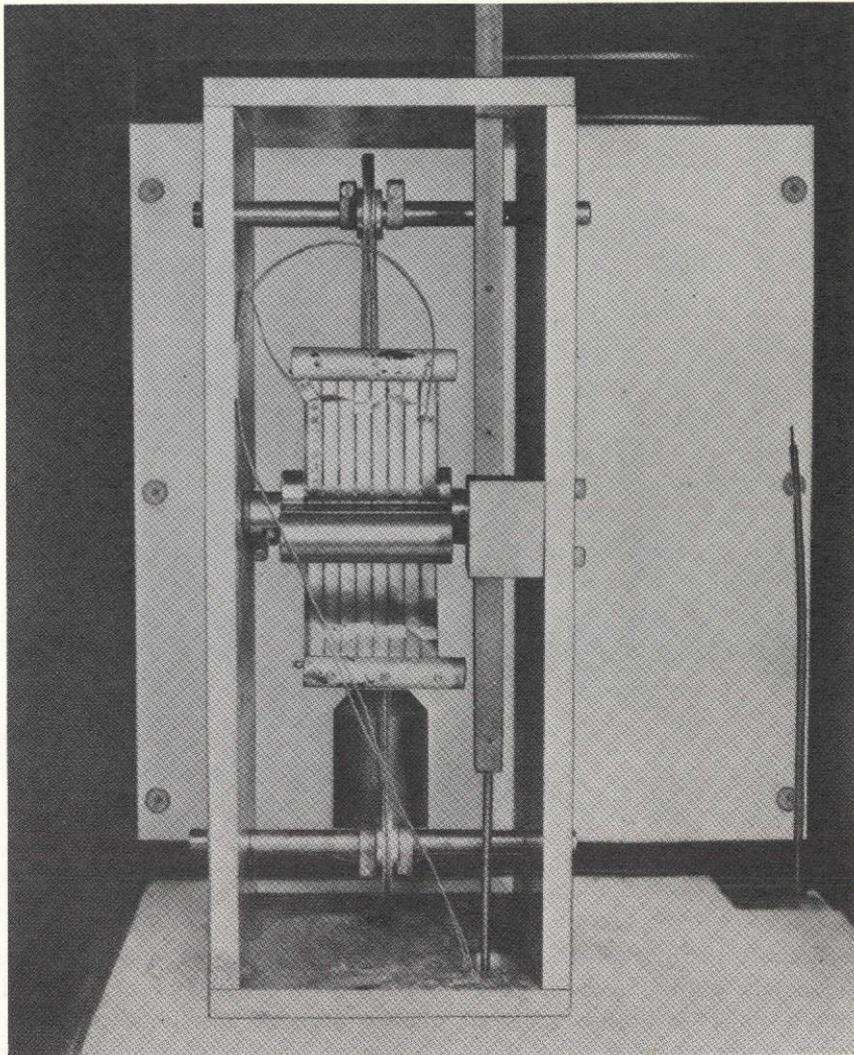
After the end of the cable is trimmed square, the cable is placed between the tool cylinder and retainer, the trimmed end flush with the cylinder

end. The cam is rotated until the cable is held firmly in position, and the blade is adjusted to shield or conductor depth, depending on the cable type. The blade is then rotated across the cable. For stripping unshielded cables, one blade adjustment is required. In this case, after each rotation the blade is moved horizontally one blade width. If the opening in the cable retainer is not as wide as the desired cable exposure width, the cable can be moved to the right, using the left stripped margin and the right side of the opening for alignment.

Source: W. Angele and C. M. Chambers
Marshall Space Flight Center
(MFS-20119)

Circle 5 on Reader Service Card.

APPARATUS TESTS FLEXURAL DURABILITY OF FCC



Durability and Continuity Tester for FCC

A new device (see figure) tests the flexural durability and electrical continuity of flat conductor cables (FCC) in a temperature-controlled environment.

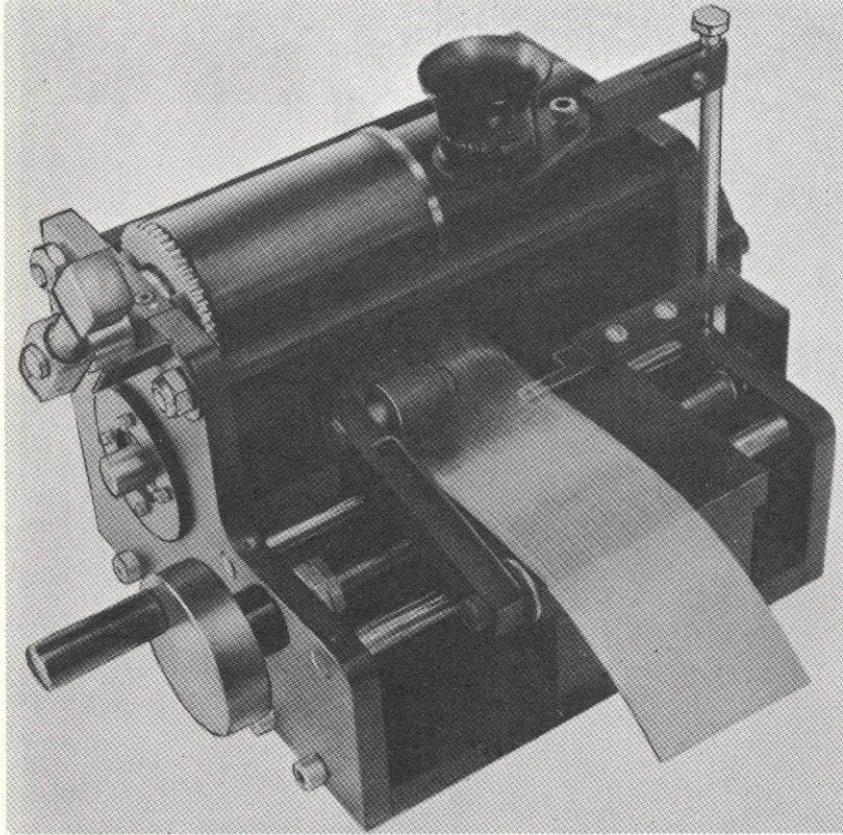
Specimens of finished cables are installed under tension in the apparatus. All conductors of the test specimens are connected in series, and a small current is applied through a continuity tester which is capable of detecting discontinuities for periods of at least 1 μ sec. The cables are flexed in two directions for a

specified number of cycles at 30 cycles per second and under any desired temperature in the range from -70° to $+250^{\circ}$ C (-94° to $+482^{\circ}$ F).

Source: C. M. Chambers and W. E. Norton
Marshall Space Flight Center
(MFS-20113)

Circle 6 on Reader Service Card.

SLITTING FLAT CONDUCTOR CABLES WITH THE SINGLE CUTTING EDGE SLITTER



Single Cutting Edge Slitter

Occasionally, it is necessary to slit a length of flat conductor cable into various widths to form cable branches. This requires a small, inexpensive, bench type flat conductor cable slitter which has the capability of accurately cutting various compositions of insulation to within ± 0.05 mm (0.002 in.).

A manually operated slitter was developed (see figure) which can cut a single slit to the desired length. The lateral position of the flat conductor cable is adjusted with the aid of an optical magnifier and a cursor glass to ensure that the slit is accurately placed between the conductors.

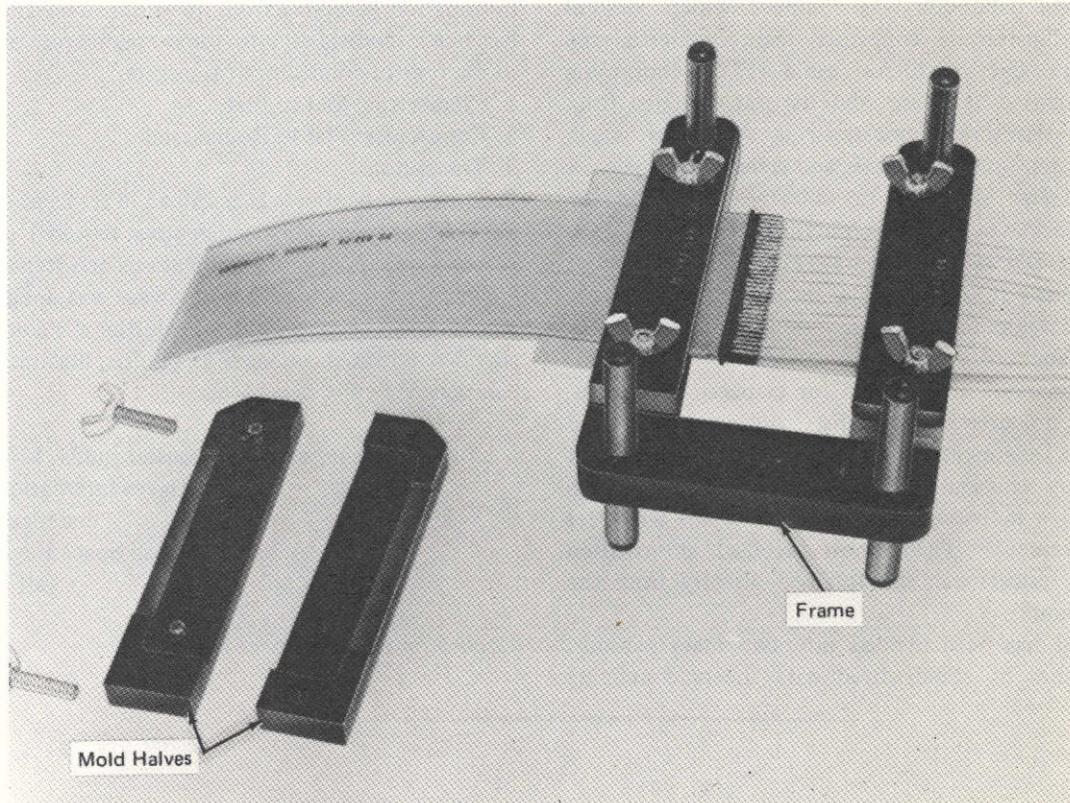
The flat conductor cable to be slit is placed under the cursor glass and the rubber guide roller. The guide roller is spring loaded and is designed to keep the cable in position during the slitting operation. The cable is placed against a guide edge of the table, and the table positioning handwheel is rotated so that the desired location

of the slit is directly under the cursor hairline. The cable is then moved forward to the cutting edge and the cutter engaging handle is pulled down toward the operator. The cutter rotation handwheel is turned, pulling the cable forward, until the desired slit length is attained. The cutter engaging handle is then lifted and the slit cable removed. The slitter is designed to cut single slits; however, multiple slits may be formed by repeating the procedure as outlined for a single slit.

Source: W. Angele and C. M. Chambers
Marshall Space Flight Center
(MFS-20111)

Circle 7 on Reader Service Card.

HANDLING FIXTURE FOR SOLDERING ROUND WIRES TO FCC



Handling Fixture

A handling fixture or frame facilitates the soldering of flat conductor cabling (FCC) to round wires. The fixture holds both the FCC and the round wires in position until after the contacting conductor ends have been soldered and the junctions have been potted. It provides for proper spacing of the wires and adequate access for soldering, prevents excessive stressing of the soldered joints during fabrication, and positions the mold halves during the potting operation.

The FCC ends to be soldered are stripped and fitted with a conventional window piece, a conductor spacer, and an insulator. Conductors of the terminated assembly are tinned and the assembly is clamped into position from the right side of the fixture. Upon completion of the soldering process, the assembly, still clamped in the holding fixture, is positioned between mold halves and encapsulated with the desired potting resin. The mold halves and handling fixture are removed after the potting material has fully cured.

Accessories are provided with the basic handling fixture to enable soldering of the following FCC-to-round-wire transitions:

- (a) all unshielded wires to two cables;
- (b) all shielded wires to two cables (alternate conductors must be skipped);
- (c) all unshielded wires to one cable and all shielded wires to a second cable; and
- (d) combination of unshielded and shielded wires to either one or both of two cables.

Source: H. G. Martineck and R. Loggins
Marshall Space Flight Center
(MFS-20118)

Circle 8 on Reader Service Card.

FLAT CONDUCTOR CABLE CONNECTOR SURVEY

A design handbook was compiled which contains data and illustrations concerned with commercial and government flat conductor cable (FCC) connecting and terminating hardware. Material was obtained from a NASA sponsored, industry-wide survey in which approximately 150 companies and government agencies were contacted. The specific objectives of the survey were to locate current and potential sources of FCC connecting and terminating devices within government and industry, to obtain data on available items and those in development, and to compile the material into a design handbook.

The handbook is intended for managers, engineers, designers, procurement specialists, and other interested personnel. Document format has been designed so that coverage by item and producer is comprehensive enough to enable an individual to select items which will meet his requirements. Then, more detailed information (including prices) can be obtained directly from the manufacturers.

Material has been divided into two main sections. One consists of standardized data sheets containing

information compiled from questionnaires. This section has been subdivided into three major areas according to the type of connector or transition:

1. Connectors: Flat to Flat,
2. Connectors: Flat to Round, and
3. Transitions.

Each item of hardware is described in terms of electrical, physical, and operating parameters; required cable end preparation; applicable specifications and standards; and applications for which the hardware was designed. The second main section contains additional manufacturer-supplied information, such as photos, illustrations, and component family data sheets.

Source: C. R. Swanson and G. L. Walker of
Hayes International Corp.
under contract to
Marshall Space Flight Center
(MFS-22493)

Circle 9 on Reader Service Card.

FLAT CONDUCTOR CABLE FOR ELECTRICAL PACKAGING: A REPORT

A new report summarizes the current status of flat conductor cable (FCC) as a component of electrical packaging systems, where it offers the advantages of low weight and volume, high reliability, and low cost. FCC basically is intended for the interconnection of equipment boxes, rather than for point-to-point internal wiring. To obtain the full advantages of FCC, in accordance with the report, a new approach to wiring systems design and harness manufacturing is needed.

The report discusses the fabrication of shielded and unshielded FCC, describing laminated, woven and extruded types. Material on several shielding techniques is

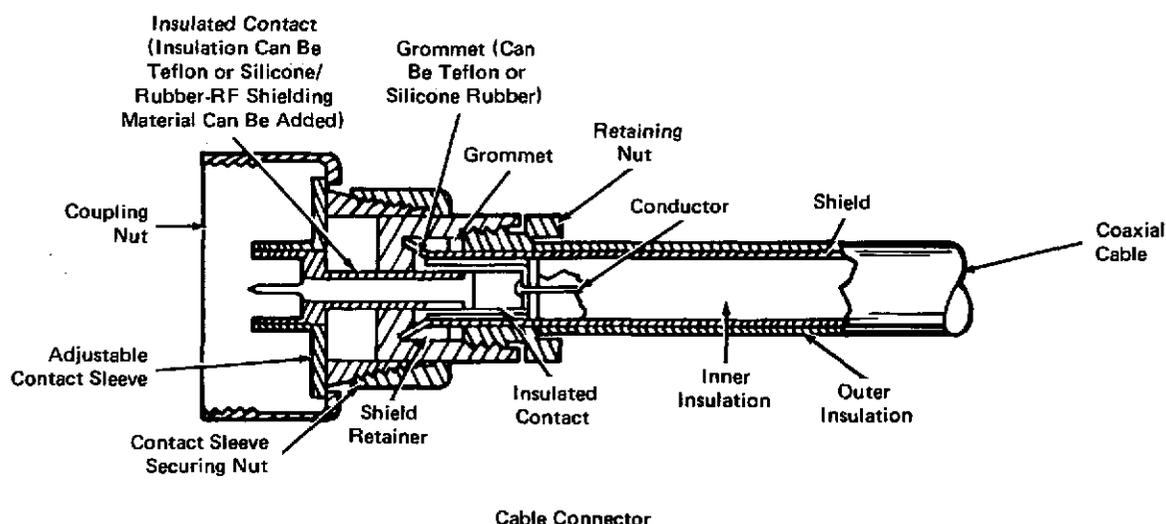
included. Transition hardware, to facilitate the interconnection of FCC and existing round-wire systems, and connectors have been developed, to accommodate a number of cable sizes and conductor gauges. One new connector operates at 600 VAC and has sealed contacts. Mil specs and standards have been published for both cable and connectors.

Source: W. Angele
Marshall Space Flight Center
(MFS-22221)

Circle 10 on Reader Service Card.

Section 2. Connector Technology

A PROPOSED ADJUSTABLE RF CABLE CONNECTOR



Cable Connector

RF transmission through impedance mismatched lines will result in power loss. In systems that require negligible loss, it may be necessary to adjust the cable length to an exact multiple of the transmitted wavelength. Thus, reflected waves will be in phase with the transmission, and no destructive interference will occur. The adjustment involves the time-consuming process of adding to and cutting from the cable until trial and error result in the exact required length.

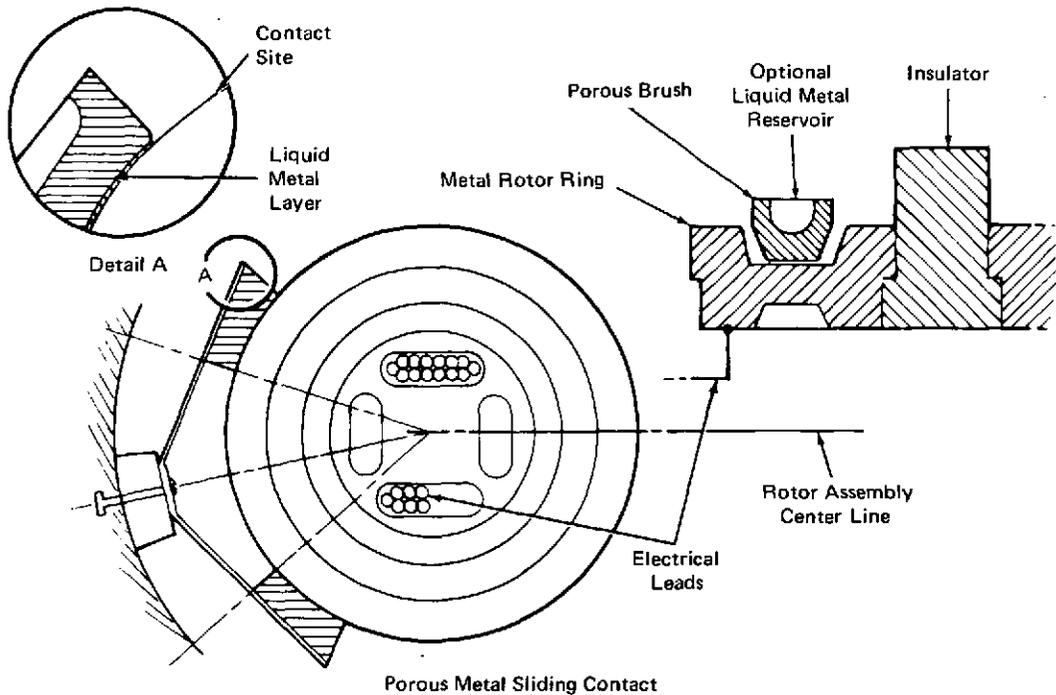
A proposed adjustable cable connector could save considerable time and cost by eliminating the need to add to or cut from the cable. The connector is shown in the accompanying illustration. To make the proper adjustment, one first calculates the approximate length. The connector is assembled and installed, and the correct impedance is found by turning an adjusting screw to move the contact sleeve in or out.

After the exact cable length is reached, the securing nut is tightened to fix the position of the assembly. The device was especially designed for use with high frequencies (i.e., UHF, VHF). For any particular application, a connector of suitable dimensions should be used.

Source: E. J. Stringer and J. D. Doyle of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24271)

Circle 11 on Reader Service Card.

LIQUID METAL POROUS MATRIX SLIDING ELECTRICAL CONTACT: A CONCEPT



Porous Metal Sliding Contact

Two types of slip rings are conventionally used to provide an electrical connection between the stationary and rotating parts of electrical machinery. One type uses a solid, electrically conductive brush and mechanical slip ring assembly to make the electrical contact between the rotating parts. The other type makes use of a liquid metal in the intervening space between the rotor and brush to provide the electrical path between the two members. Both have operating limitations.

Solid mechanical slip rings are subject to wear, high friction forces, electrical noise, debris formation, tendency to vacuum weld when static, and difficulty in retaining surface coatings in extended use. Present liquid metal slip rings are subject to debris formation, difficulty in retaining the liquid metal in the desired location and shape, and exposure of a relatively large liquid metal surface area promoting vaporization and contamination.

This concept utilizes a porous metal or nonmetal matrix containing liquid metal in the porous structure and which confines the liquid metal to the contact area between rotor and brush by capillary forces.

The figure shows a conceptual assembly employing a porous metal brush filled with liquid gallium in contact with a solid metal rotor. The pore size and direction of the porous matrix grade and the brush-rotor separation are selected to provide for the proper direction of

liquid metal flow into the contact space between rotor and brush under the influence of capillary forces. The edges of the brush at the contact site and the brush-rotor separation are designed to retain the liquid metal at the moving contact site only and reduce its exposure to the operating environment.

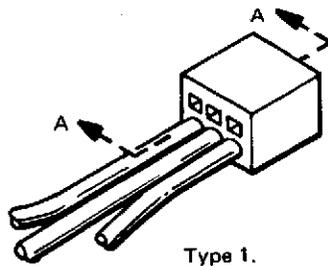
Alternate configurations and designs include the use of porous metal rotors with porous metal brushes, or porous metal rotors and solid metal brushes. The system may also be used to lubricate bearing systems.

This application has advantages over conventional mechanical slip rings in reduced friction, reduced wear, reduced electrical resistance, and ease of fabrication due to fewer complex mechanical parts. Advantages over conventional liquid metal slip rings include reduced exposure of the liquid metal to contaminants, reduced debris accumulation, location and exposure of liquid metal surfaces only in the vicinity of the contact site, and more intimate contact of liquid metal with solid components.

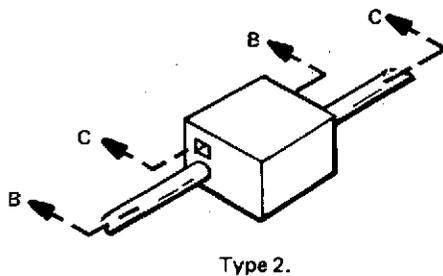
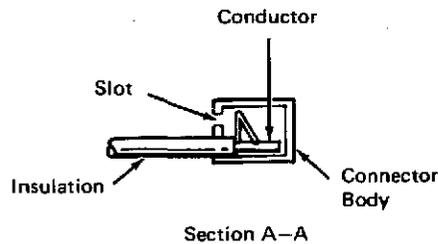
Source: Harold Ferguson
Lewis Research Center
(LEW-11735)

No further documentation is available.

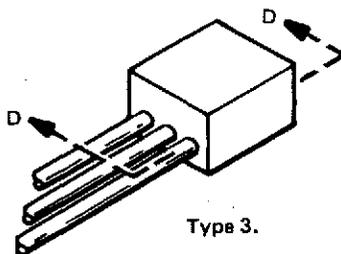
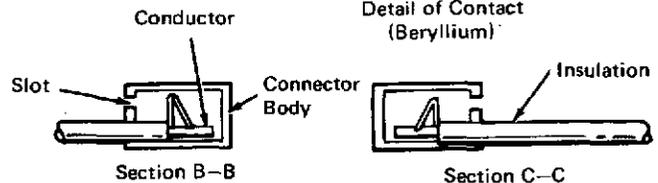
IMPROVED ELECTRICAL CONNECTOR



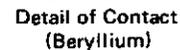
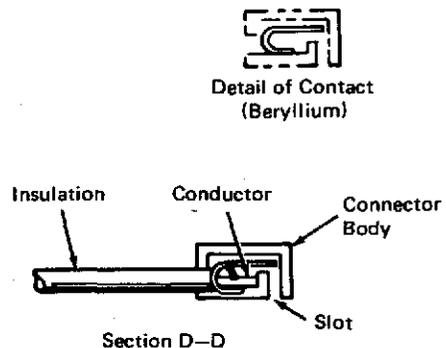
Type 1.



Type 2.



Type 3.



Present bombshell termination devices generally are designed to screw on or to snap on two or more electrical conductors, to provide electrical and mechanical contact. The conductors often must be twisted, and there is no assurance of positive contact or locking when various sizes of wires must be joined. The entire termination must be disassembled even if only a single conductor is to be changed.

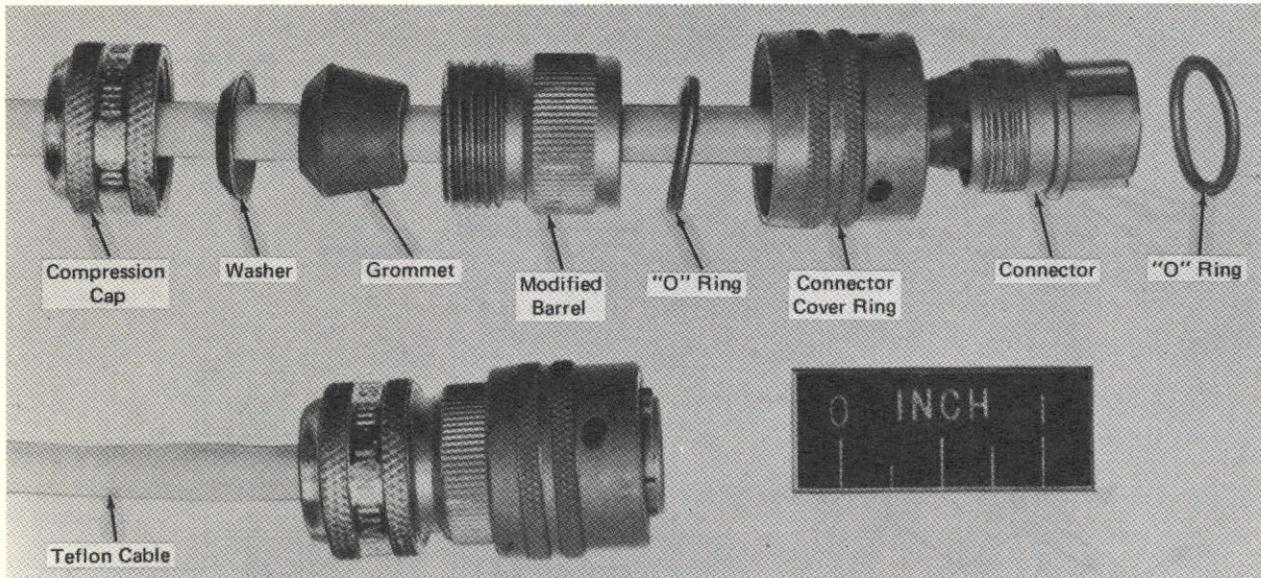
A new concept makes use of a molded, polymeric connector body into which each electrical conductor may be inserted separately and firmly locked, to provide electrical contact with other conductors. Each conductor, however, can be removed easily, if necessary,

by inserting a small tool in a removal slot. Different wire gauges can be used, and there is no twisting or damage to the conductors. Such a device would have application wherever the interconnection of electrical wiring is required. The illustration shows three different types of insertion devices incorporating the idea.

Source: E. J. Stringer of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24212)

Circle 12 on Reader Service Card.

WATERTIGHT LOW-COST ELECTRICAL CONNECTOR



Hybrid Electrical Connector

A small, inexpensive, waterproof electrical connector assembly has been designed for use with Teflon-jacketed cables that will withstand the following environment.:

1. pressure from $1.8 \times 10^3 \text{ N/m}^2$ (0.25 psia) vacuum to atmospheric;
2. temperature from 280 K (50° F) to 450 K (350° F);
3. exposure to saturated steam 450 K; and
4. the effects of saturated steam suddenly introduced into the vacuum.

Commercially-available waterproof connectors will keep out rain and other "undriven" contaminants, but will not seal under the specified conditions. Available watertight connectors are expensive and quite large in size. Readily-available potting materials will not endure throughout the 280 K to 450 K (45° to 350° F) temperature range because their thermal expansion characteristics are not compatible with those of the Teflon cable. The potting material seal is further degraded by the pressure cycle with the water vapor being forced into the fitting.

These problems may be overcome by modifying and combining component parts from different standard electrical connectors. Three areas of the connector assembly must be made watertight: the cable entry, the threaded joint between the barrel and the connector cover ring, and the connector interface.

These three areas are sealed in the following manner:

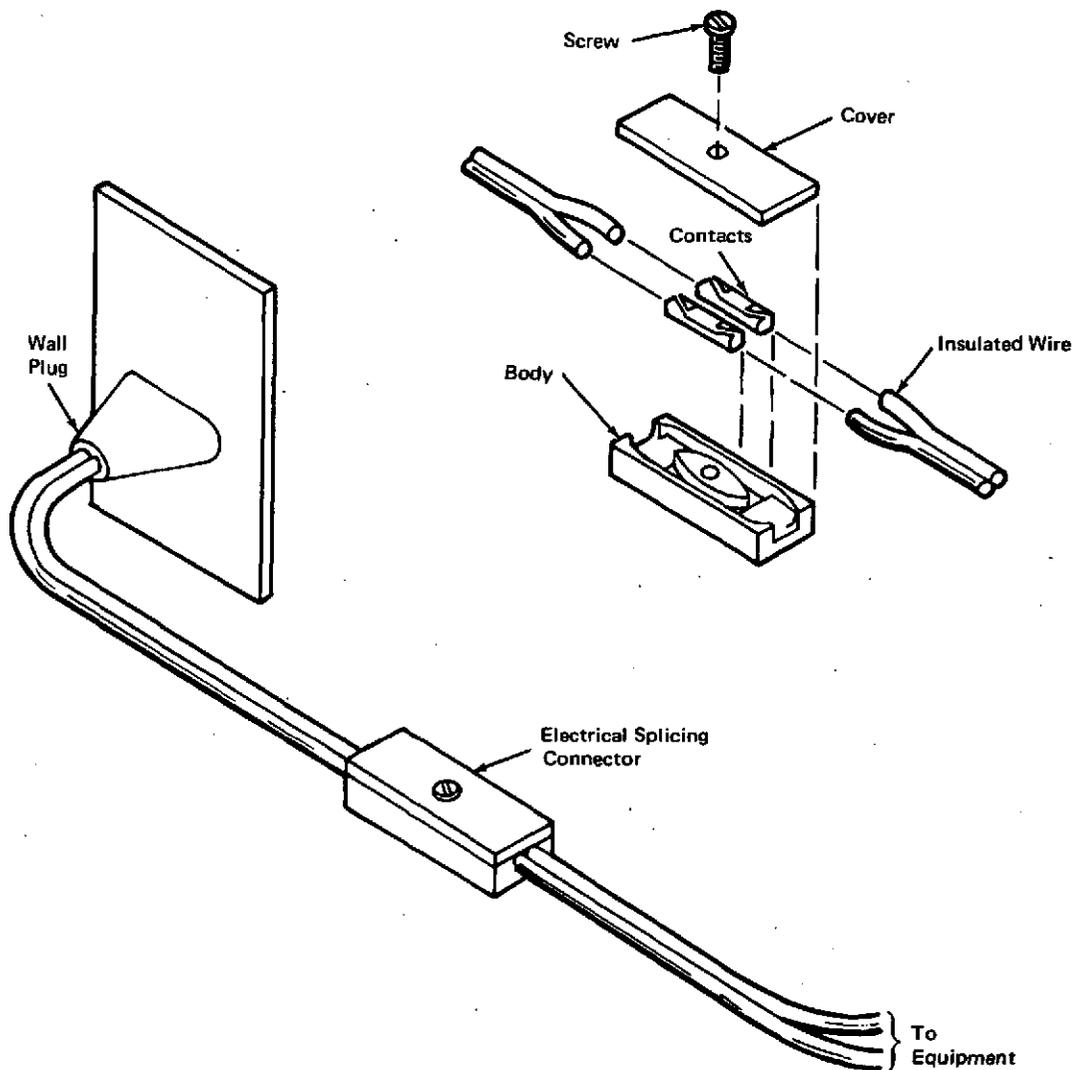
1. To the cable entry, a standard cable sealing grip is welded to a standard connector barrel. This unit, with its threaded cap, metal washer, and grommet seal, provides a tight seal around the cable. This seal also has an advantage over other methods in that it maintains a uniform grip around the cable that does not deform the cable.
2. To the threaded joint between the barrel and the connector cover ring, an "O" ring is installed in the molded lip and groove provided by the standard parts.
3. To the connector interface, an "O" ring is placed between the mating connectors.

These hybrid connectors can be fabricated readily; all of the parts are readily available from commercial sources. In addition, for quantity production, the male portion of the cable sealing grip and the connector barrel can be machined in one piece.

Source: James E. Dudenhofer and Mario N. Miraldi
Lewis Research Center
(LEW-11552)

No further documentation is available.

ELECTRICAL SPLICING CONNECTOR



Electrical Splicing Connector

A self-splicing connector in a molded body is illustrated in the figure. The splicer is a potential product for the do-it-yourself market. It is easy to use and not easily damaged. Furthermore, the protective polymeric housing acts as an insulator, eliminating the need for insulating tape.

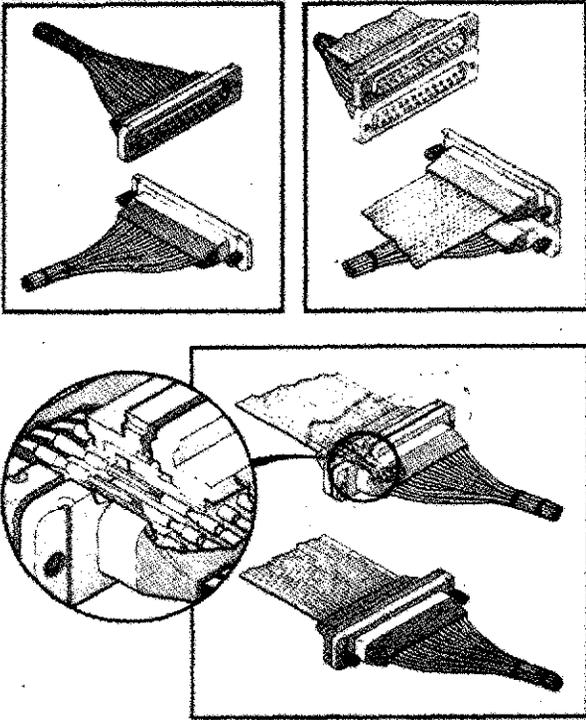
To use the splicer, the end of two wires are cut flush, leaving the insulation unstripped. The splicer contacts are opened at both ends, and the cut wires are inserted. The ends are crimped until the sharp double prongs at both ends of the contacts pierce the insulation, making contact with the conductors. The contacts, with the wires, are then placed into their respective

grooves in the connector body, pushed down, and covered. The cover is held in place by a screw; and when this assembly is secured, the in-line electrical circuit is complete.

Source: E. J. Stringer of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24254)

Circle 13 on Reader Service Card.

IMPROVED UNIVERSAL ELECTRICAL CONNECTOR



An improved universal electrical connector is suitable for all types of cable and, with a variety of inserts and pin styles, can be used over a wide range of environmental conditions.

The novel rectangular connector (see figure) can be used with both round and ribbon cables, and can be mounted on printed circuit boards or to either face of a bulkhead. Although the connector offers a high pin density-to-size ratio, terminal connections are simple and are easily made. Hermetic sealing and potting assures a pressure-tight seal over a temperature range from 200 to 478 K (-100° to 400° F). The connector provides constant electrical contact under severe vibration conditions.

The outer shell of the housing is constructed of anodized 6061 aluminum, to provide strength for the connector and to house the contact pins and insulation. A retainer clip holds together the male and female halves of the connector over an O-ring seal; a second O-ring seals the connector to the bulkhead. A potting boot surrounding the connector serves as a mold for epoxy resin and becomes part of the connector, acting as a hermetic shield against the environment. The contact pins may be soldered, crimped, or welded; and each may be shielded from radio frequencies with all shields connected to a common ground. The flat connecting surfaces facilitate soldering when round conductors are to be connected to flat conductors. The two rows of terminals simplify soldering, welding, or crimping from either side. The gold-plated steel pins are held in contact by pressure springs and will withstand vibration loads of up to 30 g.

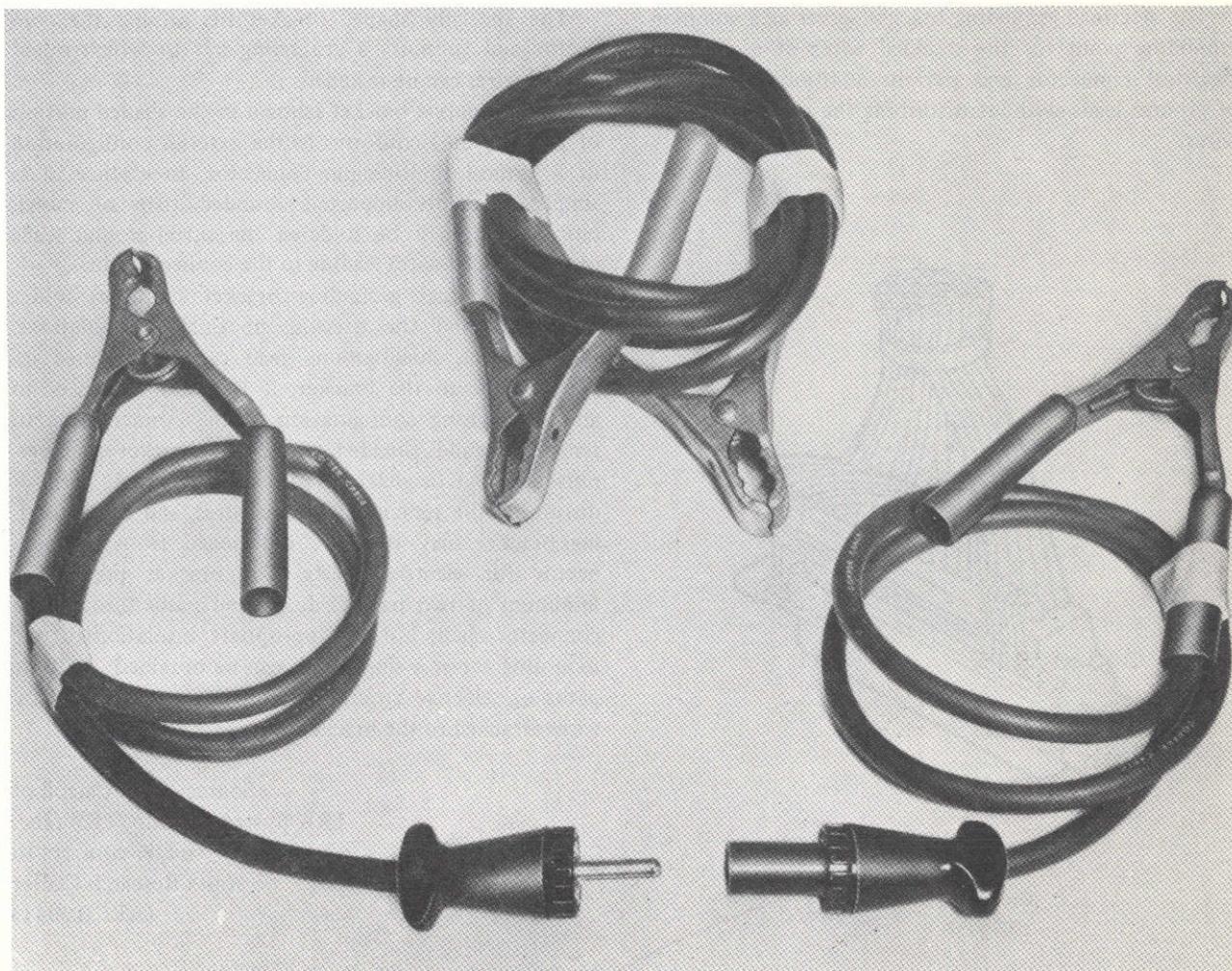
The sealant or potting compound is a copolymer of trifluoronitrosomethane and tetrafluoroethylene cured with benzoic acid. The insert is made of a fluorocarbon polymer such as Teflon, but materials such as nylon, diallylphthalate, glass, or mineral-filled epoxy resin may be used. In experiments, the Teflon/copolymer combination has been found to be nonflammable in a 1.13×10^5 N/m² (16.5 psi) oxygen environment. Silicone rubber has been used in some versions of the connector with a bake-on primer used to obtain adhesion between the gold contact pins and the silicone insert.

The connector can be assembled in the field since the epoxy potting compound can be poured by hand.

Source: B. W. Kennedy
Marshall Space Flight Center
(MFS-14741)

Circle 14 on Reader Service Card.

BATTERY BOOSTER-CABLE SAFETY INTERLOCK



Battery Booster-Cable Safety Interlock

Battery explosions can result from hydrogen gas ignition, when sparks are generated at battery posts during jumper-cable hookup. By locating the final connector away from the site of hydrogen generation (the battery), the possibility of such explosions can be reduced greatly. The safety of this device is contingent upon its proper use, thus a warning-and-instruction card is affixed to the cable.

One of the pair of jumper cables used is fabricated with an in-line male/female connector (see illustration). In use, all battery leads are connected to the batteries. The final connection is made by joining the two halves of the split cable, via the in-line connector, at a point

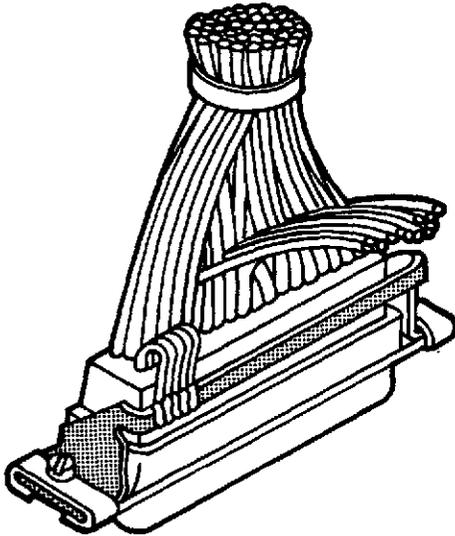
away from the batteries. The connector is a commercially available unit and is rated at 100 A, 125 to 250 V.

Source: G. H. Lehman and W. H. Reetz of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-19319)

No further documentation is available.

ELECTRICAL GROUNDING BRACKET

The electrical grounding bracket serves as a common grounding point for the shielded wires of a multipin electrical connector and permits addition or removal of ground leads without disturbing the other grounded wires.



Grounding Bracket

The specially shaped bracket fits around the connector and supports a grounding bar to which shield ground wires can be fastened.

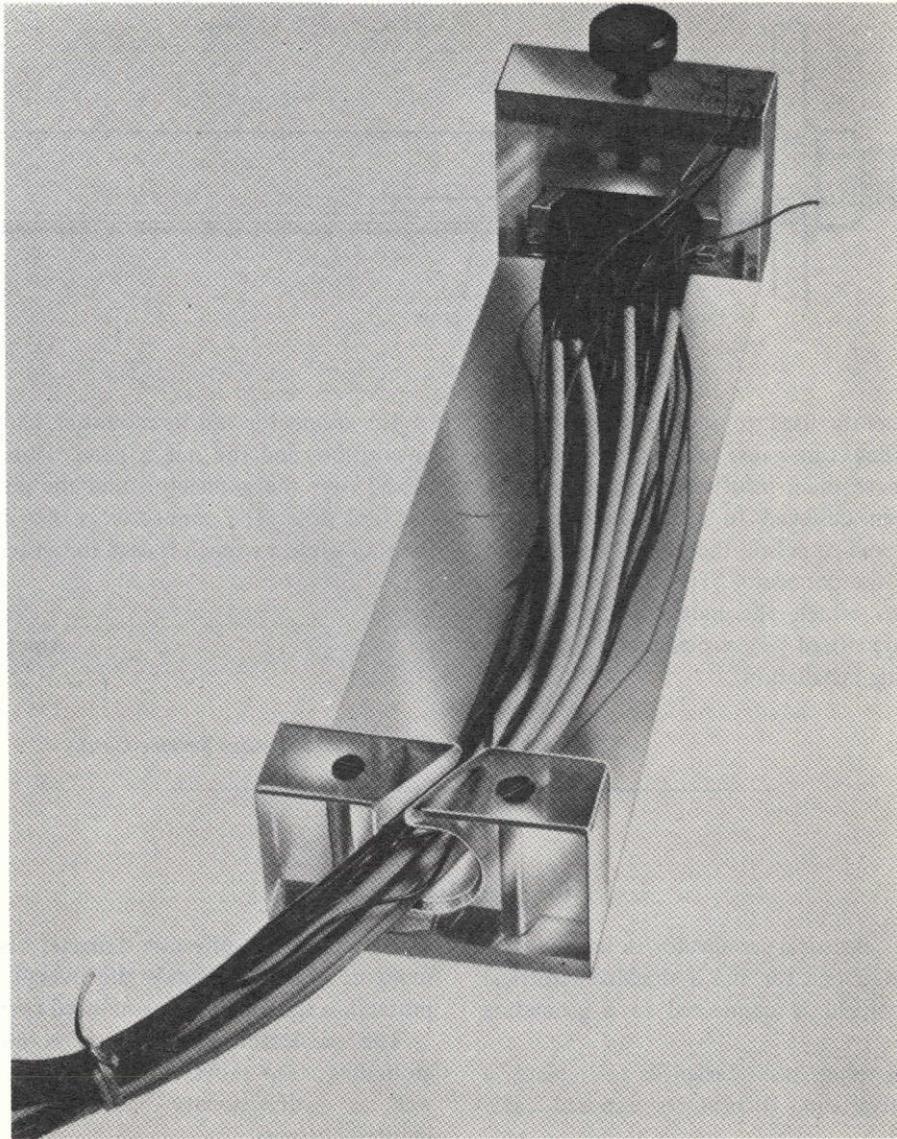
The grounding bracket (shown in the shaded portion of the diagram) conforms to the exterior configuration of a typical multiple-pin connector. In essence, it is simply a rigidly-supported rounded strip of metal, onto which may be soldered the shield-ground leads of the shielded wires leading to the connector pins.

The electrical grounding bracket simplifies solder operations and the dressing of shield terminations. Because each shield-ground lead can be soldered independently to the bracket, it is a simple matter to alter the wiring configuration of the connector or to remove or add shielded wires. The bracket also permits addition or deletion of a ground circuit without disturbing the remaining ground wires, and the grounding bracket may itself be unfastened from the connector for electrical tests. The bracket provides a minimum of two parallel dc ground paths through the connector shell, but by appropriate insulation of one mounting screw a single path can be obtained; multiple paths or selective grounding points can be obtained by wires attached to the bracket.

Source: C. E. Carroll of
TRW Systems Group, TRW, Inc.
under contract to
Ames Research Center
(ARC-10041)

No further documentation is available.

ASSEMBLY TECHNIQUE FOR ELECTRICAL CONNECTORS



Wiring Support System

When a bundle of wires is being assembled, each wire hangs unsupported until the entire bundle is completed. The side strain thus imposed on the connector grommet causes the silicone material to crack, and adhesive repair then is needed. This damage is eliminated by a new kind of collector and support as shown in the photograph.

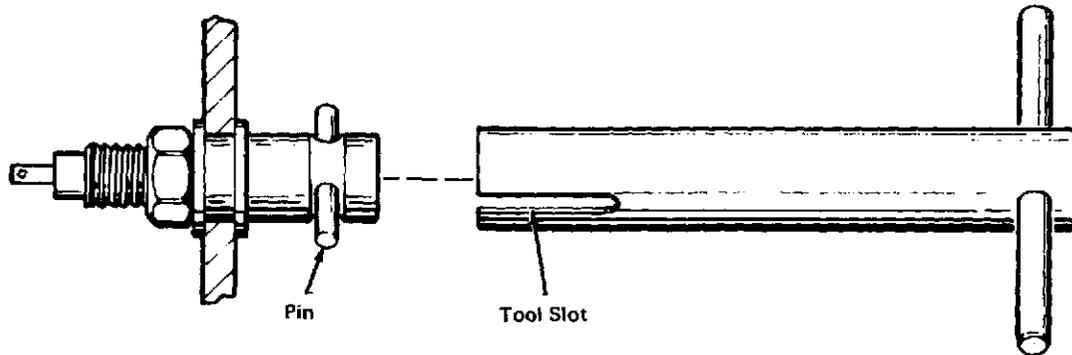
The wiring support arm, with its unique, individual-wire, collector ring and its wire entry slot, prevents side strain on the grommet before the completed wiring bundle is tied and supported. Grommet cracks are

reduced by at least 50 percent over previous preventive measures.

Source: R. H. Wright and P. R. Sutton of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17089)

No further documentation is available.

TOOL EXPEDITES INSTALLATION OF BNC CONNECTORS



Pliers are frequently used to install standard BNC connectors, but they can cause damage to the connectors and can leave them insufficiently tightened. A new tool has been designed to hold the connector during installation and to permit the nut to be tightened without damaging the connector. The tool (see figure) contains slots into which the indexing pins of the BNC connector are fitted. This prevents rotation of the connector during installation.

The connector and its mounting hardware are placed in position, and the nut is hand tightened. The tool is placed over the connector, and the pins are fitted into the tool slots. The connector is then held firmly with the tool while a wrench is used to tighten the nut.

Source: P. J. Haro
Ames Research Center
(ARC-10327)

Circle 15 on Reader Service Card.

GROUNDING PLUG

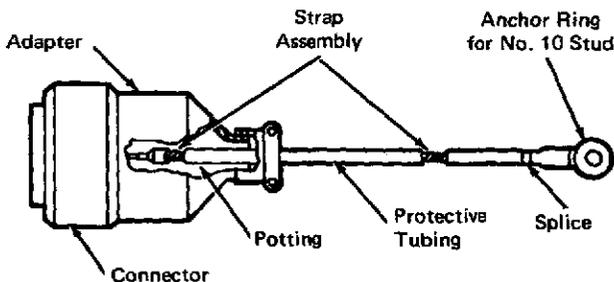
A heavy duty electrical connector/isolator incorporates a standard connector and a shielded electrical cable. The cable shield is connected to a grounding strap (see figure).

This grounding plug was designed to replace a receptacle protective cap. It protects exposed cable

connectors from physical damage, blast damage, and moisture, and it grounds the overall cable shield for protection against lightning-induced currents.

The connector configuration is novel in that the grounding strap provides a mechanical anchor point, as well as a diversionary pathway for spurious EMF-induced currents.

Possible applications include transformer grounding for electrical utility substations and the grounding of heavy duty electrical equipment used in maritime commerce, such as deck and shore winches.



Grounding Plug

Source: J. B. Potter and J. L. Alpenia of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-19226)

No further documentation is available.

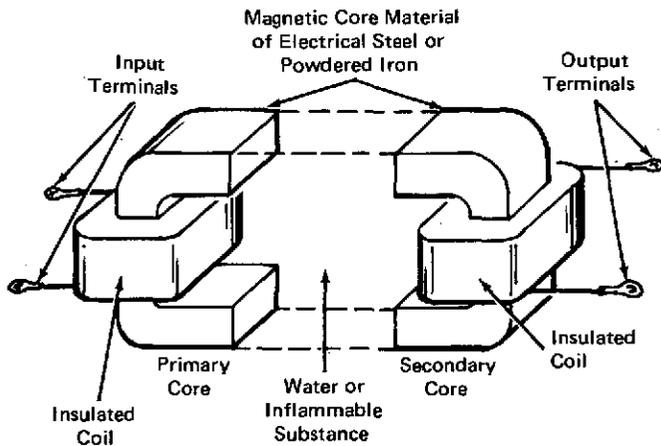
ELECTROMAGNETIC CONNECTOR

Electrical connectors are part of every electrical household appliance as well as of sophisticated electronic equipment. They are made in various sizes and shapes and provide a metal path between two or more electrical conductors. Metal connections made for electrical and electronics equipment are, however, not suitable for underwater applications nor in areas that contain explosive vapors. In the first case, the metal connection

has to be protected from the water by expensive enclosures. In the second case, metal-to-metal contact may generate sparks during handling and trigger an explosion.

The electromagnetic connector pair, shown in the figure, closely resembles an electrical transformer. It contains two iron cores that are brought together to a short distance from each other. Each iron core is wound with an insulated wire. The primary core, corresponding to a transformer primary, is the input; the secondary, corresponding to a transformer secondary, is the output.

An ac signal is "connected" through the pair across the gap by magnetic induction. Since there is no need to mechanically connect the signal circuits, the gap between halves can be water or an explosive gas. This system can be either single-phase or multiphase.



Electromagnetic Connector

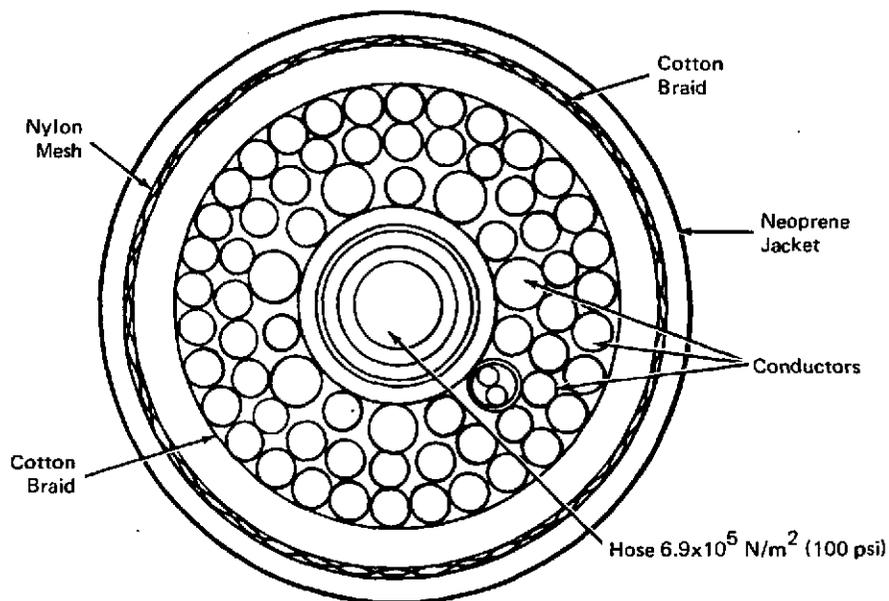
Source: W. C. Gardner of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17420)

Circle 16 on Reader Service Card.

Section 3.

Miscellaneous Wiring and Connector Techniques

NEW DESIGN FOR ELEVATOR ELECTRICAL POWER CABLES



Elevator Electrical Power Cable

In the current method of providing strain relief in elevator current-carrying traveling cables, a wire core or stainless-steel armor is used under the outer jacket of the cable. This method has several disadvantages, such as: (a) less flexible cables, (b) the need for larger diameter cables, and (c) the necessity of grounding electrical conductors through the metal armor.

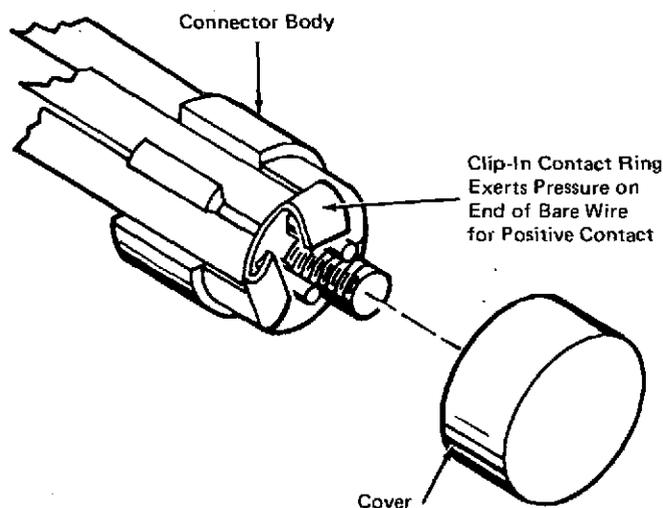
A modification in the cable design overcomes these disadvantages, by replacing the woven metal-mesh, cable-support jacket with a jacket made of woven nylon (see figure). The nylon provides fatigue-resistant

strain relief for the internal electrical conductors. Improved flexibility also facilitates the movement of the cable inside the cable trough. This new design is also adaptable to power cables used for automated and remotely-controlled industrial tools.

Source: A. M. Ehret
Kennedy Space Center
(KSC-10355)

No further documentation is available.

IMPROVED CONDUCTOR TERMINATION TAIL: A CONCEPT



Conductor Termination Tail

Commonly-used conductor termination tails employ screw-on or snap-on devices to interconnect two or more electrical conductors. Such devices do not always provide a means for determining that all the conductors are being held together to provide good continuity.

A recent concept would use a clip-in, beryllium contact ring, together with a miniature molded polymeric body-and-cap assembly. Each wire would be placed in its own slot in the conductor body and would be held firmly by the contact ring. Visual inspection then could assure that a positive electrical connection had been made. The cover would be installed then to lock the contacts and to provide electrical insulation of the assembly.

The design could be adapted to accommodate different numbers of connectors. It would eliminate the conductor breakage, due to twisting, associated with screw-on types of terminations. The polymeric body and cover could be manufactured in a variety of colors for circuit identification purposes, if desired. Such a device would be useful anywhere that the interconnection of electrical conductors is repaired.

Source: E. J. Stringer of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24232)

Circle 17 on Reader Service Card.

NONKINK ROTATOR

Electrical cords on appliances frequently kink or tangle. This happens when appliances are rotated while their plugs are fixed. Spiral cords and takeup reels help reduce cord twisting but are not always efficient or feasible. A rotating connector, called a nonkink rotator, can be used to prevent cord twist (see Figure 1).

The rotator consists of two parts (see Figure 2): (1) a plate that is attached to the appliance and (2) a rotatable housing to which the power cord is attached. The cord

is fixed in place in the housing by a conical washer. Each wire in the power cord is attached to a separate spring connector. The connectors are in contact with three metallic rings on the plate. Each ring contains a screw-mounted terminal to which the appliance wires are attached. A flathead, shoulder screw holds the plate firmly on the appliance while allowing the housing to rotate.

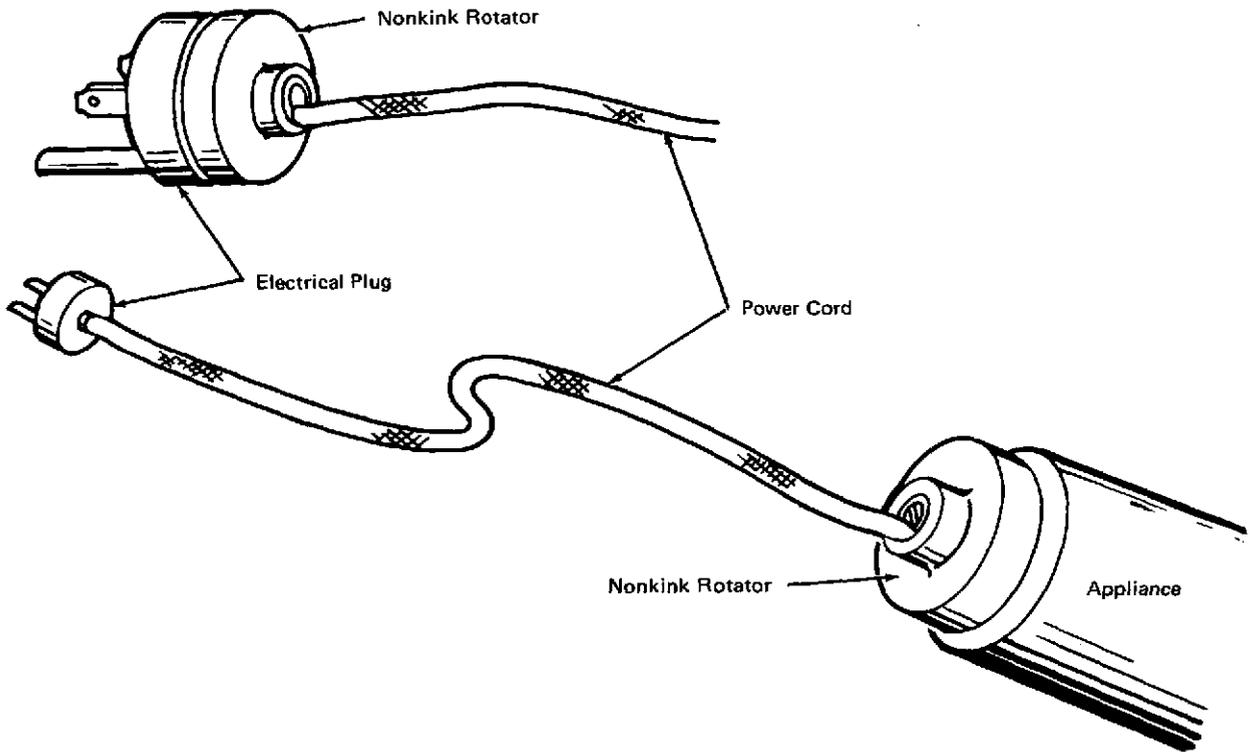


Figure 1. Nonkink Rotator at Either End of Cord

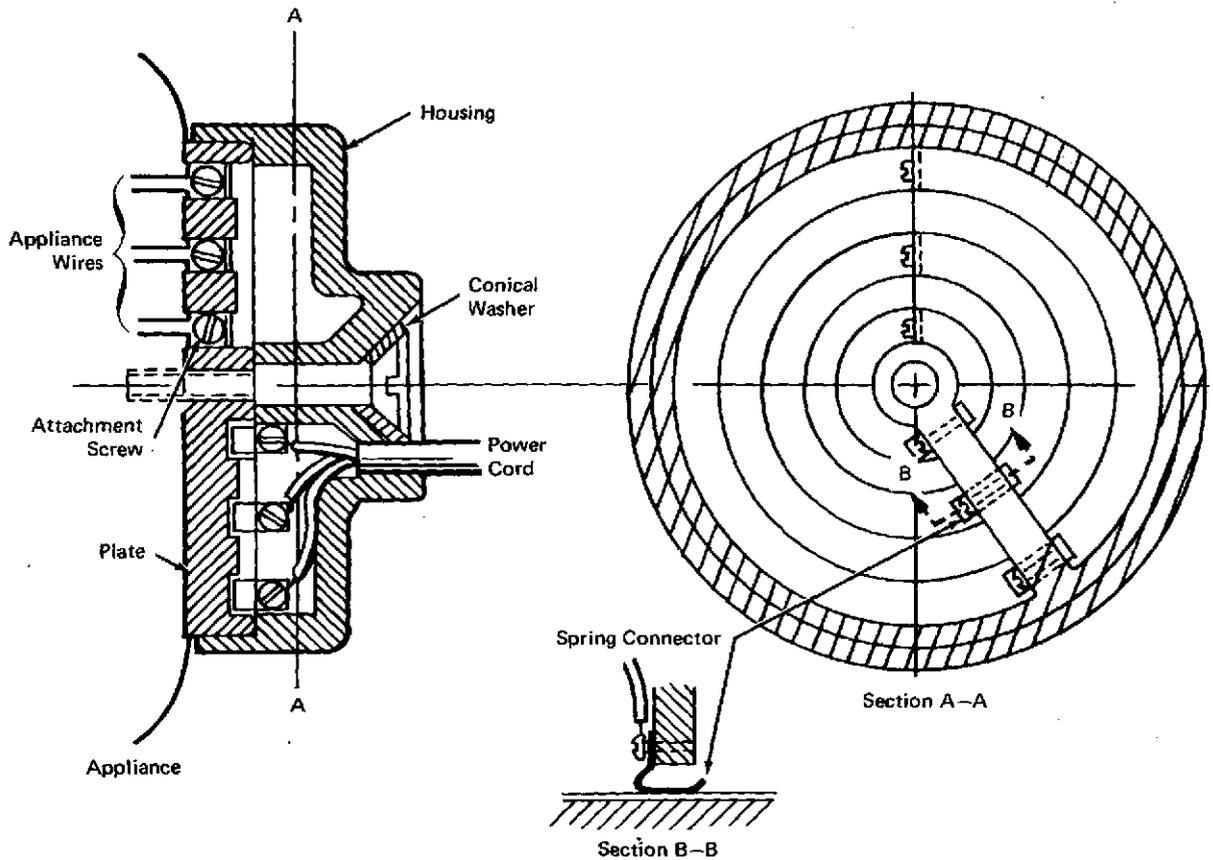


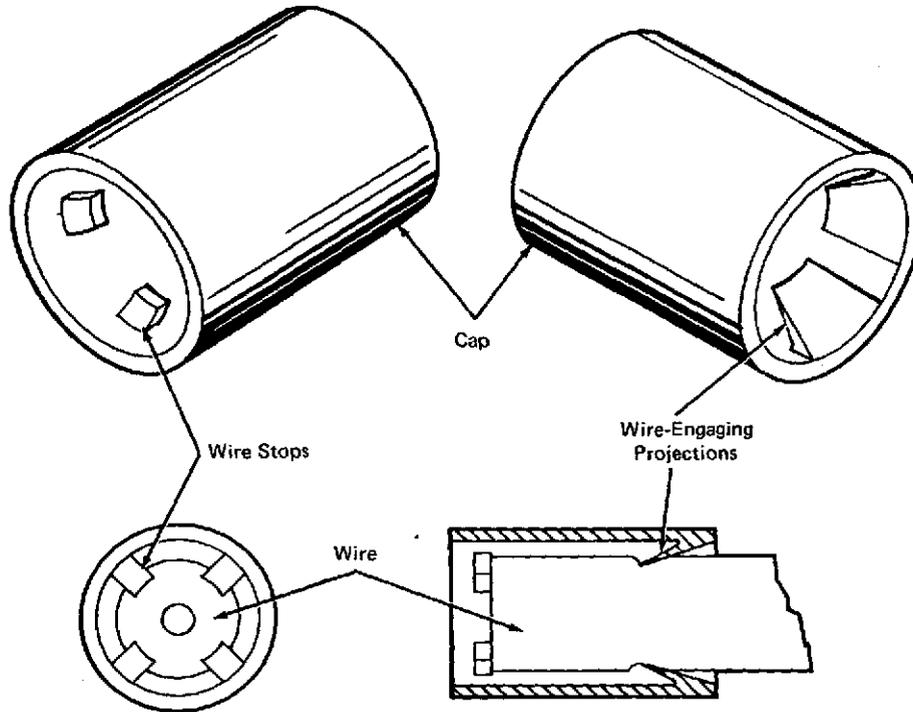
Figure 2. Nonkink Rotator, Inside View

A lip on the housing prevents dust accumulation. O-rings at the plate-to-housing contact can be used for waterproofing. In addition, the arrangement can be reversed, for instance on extension cords, by putting the rotating end at the plug (see Figure 1).

Source: E. T. Neal and R. T. Ferry, Jr., of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10705)

No further documentation is available.

WIRE INSULATION CAP: A CONCEPT



Wire Insulation Cap

Unconnected wires with bared ends must be insulated with caps. A wire cap is usually crimped after installation, a time-consuming process when the wire is part of a wrapped bundle.

A new kind of insulating cap is shown in the figure. It is made of a stiff but resilient resin, such as polycarbonate or polyamide. Four projections engage the wire at one open end of the cap. These barblike projections allow the wire to be inserted, with some resistance, to four stops. Once inserted, the cap will not separate from the wire under normal use.

The cap can be injection molded easily, since the stops are not longitudinally aligned with the projections.

Several cap sizes will be needed to accommodate different wire sizes, although a cap should tolerate small variations in wire diameter. The possibility of singlehand insertion without tedious disassembly is a special advantage when working with wrapped bundles.

Source: L. W. Rabb and R. T. Ferry, Jr., of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10583)

No further documentation is available.

FLAMMABILITY CONTROL FOR ELECTRICAL CABLES AND CONNECTORS

Unprotected electrical cables and connectors are a serious fire hazard in an oxygen-enriched atmosphere. The basic reason is that electrical cables and many connectors are insulated with nonmetallic materials which easily ignite and burn in the oxygen-concentrated surroundings. One common method for containing such fires requires that electrical wiring be enclosed in conduit and metal boxes. This procedure is costly, adds unnecessary weight to electrical systems, and complicates maintenance.

A new technique of covering fire-hazardous sections of electrical wiring with fireproof materials prevents fires from spreading in oxygen-enriched atmospheres and eliminates the use of heavy metal enclosures.

The first step in this technique requires a thorough examination of the entire electrical and electronics wiring that will be exposed to the oxygen-enriched atmosphere. Next, all of the sections that present a fire hazard along the cables and connectors are located. Once located, several types of nonflammable materials are used to cover these sections, depending on the type of wiring and connectors.

One material used to cover the potting on connectors is made from a Teflon-coated Beta cloth. The cloth

comprises special nonflammable fiberglass. It is wrapped around connector interfaces in a double layer and sewn with a Teflon-sewing thread. Other components covered with this material include exposed wire bundles and toggle and rotary switches. The material is also used to fill holes that pass wires into panels.

Another material used to cover the potting on ground terminals is Fluorel, a nonflammable fully-saturated fluorinated polymer. Other wire bundles not covered by these nonflammable materials are protected by aluminum or polyimide enclosures.

The technique may be of interest to designers of electrical and electronic equipment that will be used in oxygen-enriched environments, such as in hospitals, aircraft, underwater systems, and spacecraft. It is described in detail in an available document.

Source: W. O. Wick and D. L. Buckey of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-21584)

Circle 18 on Reader Service Card.

COMMUNICATION UMBILICALS

Umbilicals connecting headsets and/or biomedical sensors for hardline short-distance communications have been fireproofed, thus allowing such umbilical communication systems to be used by firemen or rescue workers. The umbilicals have simple strain relief, and one design includes an integral push-to-talk actuator and a volume control. Also, one type of umbilical may be plugged together, end to end, to increase total length. Possible uses are in aircraft, oxygen chambers, and explosive atmospheres.

Novel features of the umbilicals are the clamps used on the connectors at the ends, the actuator-housing

designs, and the design of the strain relief. The application of NBG tubing and the modification to the seal plugs, which are used to reduce coupling forces, are also new.

Source: W. O. Wick, D. A. Pelhank,
J. F. Dicks, and H. H. Roensch of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-21644)

Circle 19 on Reader Service Card.

MANUFACTURE AND QUALITY CONTROL OF INTERCONNECTING WIRE HARNESSSES

A four-volume series of documents has been prepared as a standard reference for the manufacture, installation, and quality control of wire harnesses. Volume I covers harnesses enclosed in fluorocarbon elastomer, harnesses enclosed in TFE convolute tubing lines with fiberglass braid, harnesses enclosed in convolute tubing, and harnesses that are enclosed in convolute tubing and are partially open-bundle (not enclosed).

Harnesses discussed in Volume II are the open-bundle type; in Volume III, harnesses enclosed in TFE heat-shrink tubing and in flexible armor are discussed; and Volume IV discusses flat conductor cables.

Each volume may be used separately and covers wire and cable preparation as well as harness fabrication and

installation. Manufacturing flow diagrams depict several alternate procedures from materials acquisition to final systems compatibility tests. The parts, materials, tools, and components used in harness manufacturing are identified and discussed. Each volume contains similarly organized information on every phase of harness wiring and includes many helpful illustrations. This series should be a useful addition to the libraries of manufacturers of electrical and electronics equipment.

Source: Marshall Space Flight Center
(MFS-22511)

Circle 20 on Reader Service Card.

Patent Information

The following innovations, described in this Compilation, have been patented or are being considered for patent action as indicated below:

Improved Universal Electrical Connector (Page 16) MFS-14741

This is the invention of a NASA employee, and U.S. Patent No. 3,568,131 has been issued to him. Inquiries concerning license for its commercial development may be addressed to the inventor: Mr. Bobby W. Kennedy, NASA, Marshall Space Flight Center, Alabama 35812.

Electrical Grounding Bracket (Page 18) ARC-10041

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)] to the TRW Systems Group, TRW, Inc., One Space Park, Redondo Beach, California.
